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Applicants: Hans-Juergen DOBSCHAL et al.

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For: APPARATUS FOR INSPECTING OBJECTS, ESPECIALLY MASKS IN MICROLITHOGRAPHY

TRANSMITTAL LETTER

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

Attached hereto is a Substitute Specification and claims along with a marked-up version of the application. No new matter is added.

Respectfully submitted,

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Apparatus for ~~Arrangement For~~ Inspecting Objects, Especially Masks in ~~In~~ Microlithography

Cross Reference to Related Applications

The present patent application is a nationalization of International Application No. PCT/EP2004/004161, filed April 20, 2004, which is based on, and claims priority from, German Application No. DE 103 18 560.7, filed April 24, 2003, both of which are incorporated herein by reference in their entireties.

Field of the Invention

This invention relates to the field of Microlithography and to devices for inspecting objects that are disposed in a vacuum chamber.

Background of the Invention

In order to observe objects or images of objects disposed in vacuum chambers, it is necessary to either insert the observation lens and the sensor (camera) into the vacuum chamber or to observe the objects or images through a vacuum window.

This is particularly required in the case of images using extreme ultraviolet radiation (EUV) if this radiation is converted using scintillators into radiation of a different wavelength and then reproduced on the sensor using additional

optics such as described in U.S. Patent No. 5,498,923 ~~(US 5498923)~~.

If the sensor is disposed in the interior of the vacuum chamber, this leads to gas emission of, for example, ~~e.g.~~ siloxanes or hydrocarbons from the sensor. This poses a high hazard of contamination of the devices disposed in the vacuum chamber. Optical elements that are exposed to radiation that is rich in energy, particularly EUV radiation, are especially at risk.

If the sensor is disposed outside this vacuum chamber, the radiation used for the image must be guided through a vacuum window onto the sensor. As a result of the window in this case, limitations arise with respect to the quality of the optical images and the usable aperture of the imaging optics.

Summary of the Invention ~~inventive solution:~~

This problem of the prior art is solved according to the present invention, in that the scintillator itself forms the window or configures the imaging optics disposed in front of the sensor in such a manner that the imaging optics or a part of them are used to form ~~forms~~ the vacuum window.

Different configurations are possible depending on the respective tasks:~~-~~

a) The imaging lens is vacuum-tight and forms the actual window.

b) The scintillator forms the vacuum window.

The vacuum window can be designed advantageously such that it can be replaced, if the scintillator starts to age.

c) A part of the lens forms the vacuum window.

Here, it is particularly advantageous to configure the first lens of the imaging optics from the source of radiation as the vacuum window because then the remaining parts of the lens are not exposed to the vacuum. Furthermore, the first lens can be permanently arranged in the vacuum chamber and the remainder of the lens can be interchangeable in order to change the imaging conditions, for example for recording an overview image by adding other lens groups.

Using all the specified options, it is possible to arrange the actual sensor that represents a high risk of emissions and contamination outside the vacuum chamber and yet achieve a superior optical imaging quality.

Brief Description of the Drawings

Figure 1 is a schematic drawing of an inspection apparatus embodying the subject invention.

Figure 2 is a schematic diagram of a lens system forming part of the subject invention of figure 1.

Detailed Description of the Preferred Embodiments

In describing preferred embodiments of the present invention illustrated in the drawings, specific terminology is employed for the sake of clarity. However, the invention is not intended to be limited to the specific terminology so selected, and it is to be understood that each specific element includes all technical equivalents that operate in a similar manner to accomplish a similar purpose.

The present invention is explained more fully ~~elaborately~~ on the basis of figure 1.

The object field OF illuminated using an EUV source of light LQ via illuminating optics EUVBO is reproduced on a scintillator S by means of EUV optics EUVO. The scintillator converts the image of the EUV wavelength range into an image of a long-wave range, which is then reproduced on the sensor using an image lens O (i.e. micro lens). In doing so, the imaging

lens/the scintillator is used according to the invention in one of the configurations described above.

The lens O is illustrated schematically. A first optical element can form the window, which is then followed by other lens elements that are arranged outside the vacuum chamber VK and are not illustrated here.

Figure 2 illustrates an optical example for the lens O. The lens illustrated is advantageously a cement-free hybrid lens as has been described in detail in DE 10130212 A1. Its advantage is the low material expenditure involved and better optical quality. The use of a diffractive element DOE increases refraction and has an achromatising effect.

The first optical element F1/F2 and also e.g. the DOE F9/F10 can be the window of the vacuum chamber here.

Data regarding the hybrid lens (mm)

Surface	Radius	Thickness	Material	
F1	unlimited			
		1.000	Q1 (synthetic quartz)	

F2	Unlimited			
		0.3028	Air	
F3	-2.744			
		2.9773	Bk10	
F4	-3.116			
		0.0200	Air	
F5	-9.911			
		2.5723	Bk7	
F6	-5.292			
		0.0500	Air	
F7	19.699			
		2.9207	Bk7	
F8	-11.828			
		0.0500	Air	
F9	Unlimited			
		2.0033	Bk7	
F10	Unlimited			
F11	23.072			
		2.000	Nsf6	
F12	7.541			
		0.5624	Air	
F13	9.051			
		3.2297	Psk53a	
F14	-15.148			
		15.2701	Air	
F15	-4.369			
		0.500	Ssk2	
F16	-117.556			

... etc. to the tube lens (not illustrated)

It is to be understood that the present invention is not limited to the illustrated embodiments described herein. Modifications and variations of the above-described embodiments of the present invention are possible, as appreciated by those skilled in the art in light of the above teachings. It is therefore to be understood that, within the scope of the

appended claims and their equivalents, the invention may be practiced otherwise than as specifically described.

What is Claimed is:

1. Apparatus ~~arrangement~~ for inspecting ~~objects~~ an object, especially ~~masks~~ a mask in microlithography, that ~~are~~ is disposed in a vacuum chamber, the apparatus comprising:

~~where~~ a converter ~~is provided~~ for converting illuminating radiation emitted from the object into a radiation of a higher wavelength;

~~A~~ a sensor ~~is also provided~~ for recording images ~~. The~~ , the sensor being ~~is~~ disposed outside the vacuum chamber; and ~~is arranged as~~

an optical interface from the vacuum chamber, ~~to the sensor of the converter or~~ the optical interface including an image lens wherein at least one part of ~~an~~ the image lens is arranged as a vacuum window in the vacuum chamber.

2. The apparatus of ~~Arrangement pursuant to~~ claim 1, where the image lens is a cement-free hybrid lens having at least one diffractive optical element ~~DOE~~.

3. ~~Arrangement pursuant to~~ The apparatus of claim 2, ~~where~~ wherein the image lens comprises:

a first lens group having a positive refraction power; and

a second lens group having a negative refraction power ~~and~~, the second lens group being arranged downstream from the first lens group ~~are provided~~ and the first lens group ~~contains the DOE~~ containing the diffractive optical element.

4. The apparatus of claim 1, wherein the converter comprises a scintillator.

5. Apparatus for inspecting an object, especially a mask in microlithography, that is disposed in a vacuum chamber having a vacuum window, the apparatus comprising:

a converter for converting illuminating radiation emitted from the object into a radiation of a higher wavelength;

a sensor for recording images, the sensor being disposed outside the vacuum chamber; and

an optical interface from the vacuum chamber, the optical interface including the vacuum window in the vacuum chamber.

6. The apparatus of claim 5, wherein the optical interface has an imaging lens that is vacuum-tight and forms the vacuum window.

7. The apparatus of claim 5, wherein the vacuum window is defined by a scintillator.

8. The apparatus of claim 5, wherein a part of a lens defined in the optical interface defines the vacuum window.

Abstract

Apparatus for inspecting objects especially masks in microlithography that are disposed in a vacuum chamber. The apparatus includes a converter for converting illuminating radiation emitted from the object into a radiation of a higher wavelength. A sensor for recording images is disposed outside the vacuum chamber and arranged as an optical interface from the vacuum chamber to the sensor of the converter or at least one part of an image lens is arranged as a window in the vacuum chamber.

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This is particularly required in the case of images using extreme ultraviolet radiation (EUV) if this radiation is converted using scintillators into radiation of a different

wavelength and then reproduced on the sensor using additional optics such as described in U.S. Patent No. 5,498,923.

If the sensor is disposed in the interior of the vacuum chamber, this leads to gas emission of, for example, siloxanes or hydrocarbons from the sensor. This poses a high hazard of contamination of the devices disposed in the vacuum chamber. Optical elements that are exposed to radiation that is rich in energy, particularly EUV radiation, are especially at risk.

If the sensor is disposed outside this vacuum chamber, the radiation used for the image must be guided through a vacuum window onto the sensor. As a result of the window in this case, limitations arise with respect to the quality of the optical images and the usable aperture of the imaging optics.

Summary of the Invention

This problem of the prior art is solved according to the present invention, in that the scintillator itself forms the window or configures the imaging optics disposed in front of the sensor in such a manner that the imaging optics or a part of them are used to form the vacuum window.

Different configurations are possible depending on the respective tasks:

a) The imaging lens is vacuum-tight and forms the actual window.

b) The scintillator forms the vacuum window.

The vacuum window can be designed advantageously such that it can be replaced, if the scintillator starts to age.

c) A part of the lens forms the vacuum window.

Here, it is particularly advantageous to configure the first lens of the imaging optics from the source of radiation as the vacuum window because then the remaining parts of the lens are not exposed to the vacuum. Furthermore, the first lens can be permanently arranged in the vacuum chamber and the remainder of the lens can be interchangeable in order to change the imaging conditions, for example for recording an overview image by adding other lens groups.

Using all the specified options, it is possible to arrange the actual sensor that represents a high risk of emissions and contamination outside the vacuum chamber and yet achieve a superior optical imaging quality.

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lens/the scintillator is used according to the invention in one of the configurations described above.

The lens O is illustrated schematically. A first optical element can form the window, which is then followed by other lens elements that are arranged outside the vacuum chamber VK and are not illustrated here.

Figure 2 illustrates an optical example for the lens O. The lens illustrated is advantageously a cement-free hybrid lens as has been described in detail in DE 10130212 A1. Its advantage is the low material expenditure involved and better optical quality. The use of a diffractive element DOE increases refraction and has an achromatising effect.

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F6	-5.292			
		0.0500	Air	
F7	19.699			
		2.9207	Bk7	
F8	-11.828			
		0.0500	Air	
F9	Unlimited			
		2.0033	Bk7	
F10	Unlimited			
F11	23.072			
		2.000	Nsf6	
F12	7.541			
		0.5624	Air	
F13	9.051			
		3.2297	Psk53a	
F14	-15.148			
		15.2701	Air	
F15	-4.369			
		0.500	Ssk2	
F16	-117.556			

... etc. to the tube lens (not illustrated)

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appended claims and their equivalents, the invention may be practiced otherwise than as specifically described.

What is Claimed is:

1. Apparatus for inspecting an object, especially a mask in microlithography, that is disposed in a vacuum chamber, the apparatus comprising:

a converter for converting illuminating radiation emitted from the object into a radiation of a higher wavelength;

a sensor for recording images, the sensor being disposed outside the vacuum chamber; and

an optical interface from the vacuum chamber, the optical interface including an image lens wherein at least one part of the image lens is arranged as a vacuum window in the vacuum chamber.

2. The apparatus of claim 1, where the image lens is a cement-free hybrid lens having at least one diffractive optical element.

3. The apparatus of claim 2, wherein the image lens comprises:

a first lens group having a positive refraction power; and

a second lens group having a negative refraction power, the second lens group being arranged downstream from the first lens group and the first lens group containing the diffractive optical element.

4. The apparatus of claim 1, wherein the converter comprises a scintillator.

5. Apparatus for inspecting an object, especially a mask in microlithography, that is disposed in a vacuum chamber having a vacuum window, the apparatus comprising:

a converter for converting illuminating radiation emitted from the object into a radiation of a higher wavelength;

a sensor for recording images, the sensor being disposed outside the vacuum chamber; and

an optical interface from the vacuum chamber, the optical interface including the vacuum window in the vacuum chamber.

6. The apparatus of claim 5, wherein the optical interface has an imaging lens that is vacuum-tight and forms the vacuum window.

7. The apparatus of claim 5, wherein the vacuum window is defined by a scintillator.

8. The apparatus of claim 5, wherein a part of a lens defined in the optical interface defines the vacuum window.

Abstract

Apparatus for inspecting objects especially masks in microlithography that are disposed in a vacuum chamber. The apparatus includes a converter for converting illuminating radiation emitted from the object into a radiation of a higher wavelength. A sensor for recording images is disposed outside the vacuum chamber and arranged as an optical interface from the vacuum chamber to the sensor of the converter or at least one part of an image lens is arranged as a window in the vacuum chamber.